C3 Combined Sewer Overflows

This chapter primarily deals with combined sewer overflows (CSOs). Information is included on the CSO requirements of Ecology and the federal government. Planning, design, construction, operation and maintenance, and reporting considerations and requirements are also included. Other wet weather flow control issues include sanitary sewer overflows (SSOs) and stormwater. These are defined in C3-1.1 but are not discussed further in this chapter.

Figures

Tables

C3-1 General

This chapter addresses primarily combined sewer overflows (CSOs). See C3-1.1 for definitions of terms used in this chapter and elsewhere in this manual to describe wet weather flow concerns.

C3-1.1 Definitions and General Description of the Various Wet Weather Related Flows

Combined sewer systems (CSS) are wastewater collection systems designed to carry sanitary sewage (consisting of domestic, commercial, and industrial wastewater) and stormwater in a single pipe to a treatment facility. In periods of rainfall or snowmelt, total wastewater flows can exceed the capacity of the sewer collection systems and/or treatment facilities. When this occurs, the combined sewer system is designed to overflow directly to nearby streams, lakes, and harbors, discharging untreated sewage and stormwater. These overflows are called **combined sewer overflows (CSOs)**. No new combined sewers may be built.

Sanitary sewer overflows (SSOs) occur when the capacity of a separate sanitary sewer is exceeded, normally during storm events due to inflow and infiltration. There are several factors that may contribute to SSOs from a sewerage system, including pipe capacity, operations and maintenance effectiveness, sewer design, age of system, pipe materials, geology, and building codes. SSOs are considered unauthorized discharges not covered by NPDES permits, and must be reported to Ecology as spills. For a discussion of hydraulic design issues for collection systems, see Chapter G2.

Separate storm sewer systems collect and convey runoffs from rainfall or snowmelt to a **stormwater outfall**. Ecology has prepared a technical manual titled "Stormwater Management Manual for the Puget Sound Basin (SWMM*)*," 1992. This manual contains descriptions of and design criteria for best management practices to prevent, control, and treat pollutants in stormwater. Therefore, SWMM may be used for guidance on separate storm sewer systems.

C3-1.2 Background

Because CSOs contain untreated domestic sewage, commercial and industrial wastewater, as well as surface runoff, many different contaminants may be present. Contaminants may include pathogens, oxygen consuming pollutants, solids, nutrients, toxics, and floatable materials. Because of these contaminants and the volume of the flows, CSOs can cause a variety of adverse impacts on the receiving waters, such as shellfish harvesting restrictions, impairment of the aquatic habitat, and aesthetic degradation due to unsightly floating materials associated with raw sewage.

C3-1.2.1 Washington State CSO Program

Due to their intermittent nature and variable pollutant and flow characteristics, CSOs are very difficult to control. In 1987, the state legislature amended its Water Pollution Control Act (Chapter 90.48 RCW) requiring Ecology and local governments to develop reasonable plans and compliance schedules for the greatest reasonable reduction of CSOs at the earliest possible date. To implement this legislation, Ecology adopted a regulation (Chapter 173-245 WAC) which defines the greatest reasonable reduction as "control of each CSO such that an average of one untreated discharge may occur per year." This regulation also defines performance standards for the primary treatment of CSOs as "the removal of at least 50 percent of TSS (total suspended solids) from the waste stream and less than 0.3 mL/L/hr of settleable solids in the discharge.” No new combined sewer overflows are allowed.

C3-1.2.2 National CSO Control Effort

In 1994, the US EPA published its CSO control policy (59 Federal Register, 18688). The policy establishes guidelines for CSO communities to develop CSO controls. It requires CSO communities to implement, as appropriate, the nine minimum controls specified in the policy, and develop comprehensive long-term control plans tailored to their site-specific conditions. The long-term CSO control plans must achieve a level of CSO discharge control such that the state water quality standards will not be violated. Table C3-1 presents a summary of the EPA CSO Control policy requirements and compares them with requirements under Ecology’s CSO regulations.

Table C3-1. Comparison of EPA and Ecology CSO Requirements

Category	EPA CSO Control Policy Requirements	Ecology Requirements
Immediate CSO Control Measures	**Implementation and documentation of the following nine minimum controls (NMC) for CSOs:** 1. Proper operation and regular maintenance programs for the sewer system and CSOs; 2. Maximum use of the collection system for storage; 3. Review and modification of pretreatment requirements to assure CSO impacts are minimized; 4. Maximization of flow to the treatment plant for treatment; 5. Prohibition of CSOs during dry weather; 6. Control of solid and floatable materials in CSOs; 7. Pollution prevention (programs that focus on contaminant reduction activities); 8. Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts; and 9. Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.	• Chapter 173-245 WAC explicitly requires NMC Nos.1-4. • Chapter 173-245 WAC also requires the monitoring of CSO frequency and volume. • To comply with the EPA CSO policy, the appropriate NMC requirements are added to the municipalities’ NPDES permit when reissued.
Final Standard	The policy provides several options: • One of the options under the “Presumption Approach” is to reduce the average number of untreated CSOs to 4-6 events per year, and • CSOs shall not violate water quality standards. (The policy recommends adopting appropriate standards that will be protective of the water body’s beneficial uses.)	• One untreated CSO/year; and • CSOs shall not violate water quality standards (numeric standards or the beneficial uses).

Category	EPA CSO Control Policy Requirements	Ecology Requirements
Long-Term Control Plan	1. Characterization, monitoring, and modeling of the combined sewer system; 2. Public participation. (See **Note A**.) The permittee must employ a pubic participation process that actively involves the affected public in decision making to select the long-term CSO controls; 3. Consideration of sensitive areas. (See **Note A**.) Controlling overflows to sensitive areas must be given the highest priority; 4. Evaluation of alternatives; 5. Cost/performance considerations; 6. Operational plan; 7. Maximizing treatment at the existing treatment plant; 8. Implementation schedule. The Long-Term Control Plan must include pertinent information to develop the construction and financing schedule for implementation of CSO controls; and 9. Post-construction compliance monitoring program. (See **Note A**.) The monitoring program should be adequate to verify compliance with water quality standards and protection of designated uses as well as to ascertain the effectiveness of CSO controls.	• The state CSO reduction plan requirements include all except 2 and 9. • The CSO communities in the state have already developed CSO reduction plans. However, public participation as envisioned by the EPA's CSO policy was not a requirement for the development of the CSO reduction plans. • Also, the CSO reduction plans were not required to propose a program for post-construction receiving water quality monitoring.

Note A: States are given discretion not to require these steps for small CSO jurisdictions with populations under 75,000.

C3-1.2.3 CSO Discharges and Water Quality Standards

Compliance with the state water quality standards is a requirement that must always be achieved under both the state CSO regulation and EPA national CSO control policy. Compliance with the state water quality standards regulation, Chapter 173-201A WAC, is achieved by meeting the quantifiable standards as well as protecting the designated use of a water body.

C3-2 CSO Reduction Plans

To fulfill the requirements of Chapter 173-245 WAC, municipalities have to develop and receive Ecology approval for CSO reduction plans and for engineering reports. The regulation outlines the ultimate goal of the regulation, the data collection requirements, the acceptable types of control alternatives, the required comparative analyses of alternatives, and requirements for ranking and scheduling CSO reduction projects.

Municipalities with CSOs should have approved CSO reduction plans. If they do not, they should have an administrative order from Ecology which stipulates a deadline to submit such a plan. Once a CSO reduction plan is approved, any projects or actions which are scheduled for construction or implementation within the five-year life of the existing sewage treatment plant permit must be incorporated into the NPDES permit or an administrative order. CSO plans are to be amended every five years in conjunction with the municipality's NPDES permit.

Reduction schedules in CSO reduction plans should incorporate the time necessary to prepare and receive approval for project-specific engineering reports before design.

C3-2.1 Problem Assessment

Existing information must be assessed and data needs identified before ranking sites in priority order. Prioritization will determine the order and timing of CSO control projects. Where significant data voids exist, ranking and prioritization will need to be iterative.

Plans and schedules can be modified in the CSO Control Plan Update for each NPDES permit renewal (see C3-4.4). Information requirements to support ranking, prioritization, and project alternative development include the following:

C3-2.1.1 System Mapping/Inventory

- Map of receiving waters and collection system.
- Natural resources.
- Recreational areas.
- Special fish, shellfish, and habitat areas.
- Beneficial uses.
- Public water supply intakes.
- Existing discharge structures.

C3-2.1.2 Flow Monitoring and Sampling for CSO Reduction Plans

To comply with WAC 173-245-040(2)(a) municipalities should have accomplished at least the following programs.

A. Combined Sewer Overflow Discharge (Whole Effluent)

1. Basins with Commercial/Industrial Zoned Areas

- Sample each site at least twice, using a flow-paced composite sample.
- Analyze for: heavy metals (total, or dissolved and particulate) (As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn); total suspended solids; settleable solids; base/acid and neutrals (BAN) (US EPA method 624); organo-chlorine pesticides and PCBs (US EPA method 625); and polycyclic aromatic hydrocarbons (US EPA method 625).
- Record all discharge volumes and frequency.

2. Basins with Residential Zoning

- No quality sampling required if strictly residential basin.
- If a small commercial and/or industrial area is included, consider whether the businesses could generate discharge other than sanitary sewage and normal storm runoff. If so, see sampling requirements in C3-2.1.2A.1. Also consider whether past practices within the basin could contaminate stormwater runoff.
- Record all discharge volumes and frequency.

B. Receiving Water Sediments

1. Basins with Commercial/Industrial Zoned Areas

- Establish extent of sludge deposit by visually observing sediment samples or by diver inspection.
- Analyze at least one sample of the deposit for percent solids, total organic carbon, grain size distribution, and heavy metals

(for totals, see C3-2.1.2A.2.). Also run BAN, volatiles, pesticides, and PCBs (use Puget Sound Estuary Program (PSEP) Protocols Manual). Be sure to report the total concentration of polycyclic aromatic hydrocarbons (PAH).

2. Basins with Residential Zoning

Establish extent of sludge deposit by visually observing sediment samples or by diver inspection. This information may be used for qualitatively assessing the relative environmental impacts of CSOs from residential zones.

C. Access

Sampling and flow recording the actual discharge is preferable. If the discharge is not accessible, establish a relationship between flow in the sewer trunk and flow in the discharge pipe to which the trunk overflows. A sampler in the trunk could initiate when depth of flow in the trunk reaches overflow level.

D. Data Analyses

Sampling and laboratory analysis should conform to techniques in the PSEP Protocols Manual.

1. Discharge

Note that C3-2.1.2A about discharge sampling indicates total metals, or dissolved and particulate metals. Analyses for dissolved and particulate metals would provide a clearer picture of potential sediment impacts and water quality impacts.

If only total metals is available, compare the total metals data against water quality standards, sediment values, and criteria identified below. Because the medium (water or solids) in which the metals are carried is not known, compare the data against the regulatory standards for both. This gives a worst case comparison. Note that both the total metals concentration and the total suspended solids data are necessary to derive the maximum estimate of the metals concentration (mg/Kg) in the particulate fraction.

The organics analyses should be done on whole effluent samples or separately on the dissolved and particulate fractions. Note that because typical concentrations in wastewater are relatively low the laboratory may need a large sample. This is necessary to provide results in the parts-per-billion range for whole effluent samples and in the 100- and 1,000-microgram-per-kilogram range for particulates.

For estimating water quality impacts, compare the discharge’s dissolved (or total) heavy metals and organics concentrations to water quality standards (Chapter 173-201A WAC).

For estimating sediment impact, compare the discharge’s particulate (or total) metals concentrations to the sediment management standards (Chapter 173-204 WAC).

2. Receiving Water Sediments

The receiving water sediments' heavy metals and organics concentrations should also be compared to the sediment management standards.

If sediments show a high level of contamination, compare the sediment data against the hazardous waste regulations and the dredged material management standards. Locations exceeding the hazardous waste standards should be reported to the Superfund staff in the Ecology regional office.

If the samples exceed Ecology's sediment management standards but not any other standards, additional sampling should be done to determine the extent of sediments which exceed those criteria. The additional sampling should occur no later than the next five-year CSO reduction plan update if the overflow has not yet been completely eliminated. It can be assumed that the sample results reflect the relative contamination of each site. These data are being used not only for determining environmental impacts, but for prioritizing CSO sites for correction, and evaluating the appropriateness of different control measures.

E. Exemption as Allowed by WAC 173-245-040(2)(a)(iv)

This paragraph in the WAC allows suspension of the requirement to analyze receiving water sediments. The exemption can apply if other nearby sediment sources or activities (such as dredging) obscure or have disrupted CSO sediment deposition. The decision whether to require sediment analysis is the responsibility of Ecology's regional office.

F. Additional Characterization

Water quality sampling of overflows for characterization and estimate of receiving water impact should cover a range of overflow volumes, seasonal periods, and tidal conditions.

More sophisticated characterizations such as biological characterization, fate and transport modeling, and source comparisons may be useful for later refinement of project alternatives.

C3-2.1.3 Baseline Annual CSO Volume and Frequency

WAC 173-245-040 requires identification of the baseline annual volume and frequency of each discharge. The regulation defines baseline annual CSO volume and frequency as "the annual CSO volume and frequency which is estimated to occur based upon the existing sewer system and the historical rainfall record." Section 090 requires that any CSO not increase above this baseline annual condition.

C3-2.1.3A to C3-2.1.3C describe how the baseline annual condition is established, and how to determine whether that level is being exceeded.

A. Modeling

The baseline annual condition is established by correlating rainfall with overflow volume and frequency. The literature contains many examples of mathematical models that correlate rainfall with runoff. Some models include programs that simulate routing the storm runoff and sewage flows through the sewer system. From these models, we can estimate overflow occurrence and volumes for storm events.

Large communities with numerous overflow sites should use more sophisticated models. These models use hourly rainfall data to generate unit hydrographs, and routing models to lag and combine hydrographs and simulate flow backups. For small communities with only one or two discharge points, correlation of rainfall and overflow occurrence and volume may be demonstrated with simpler models or by graphical correlation of observed rainfall amounts and overflow quantity.

The sophistication of the model chosen to analyze the system must be matched to the requirements. In a complex system, preliminary screening can be conducted with simplified models, but final alternative testing and design will require use of sophisticated dynamic models (such as EPA's Stormwater Management Model EXTRAN block). In outlying tributary basins far upstream in the network, simplified models (such as EPA's Stormwater Management Model RUNOFF and TRANSPORT blocks) may be used. In larger diameter sewers and in cases where the depth of flow is important (critical overflow weirs, pump stations, storage within the sewer network), a fully dynamic model must be used.

B. Calibration

Flow and rainfall monitoring should be conducted to collect data for calibration of runoff and infiltration/inflow models. Generally, a minimum of four to six months of continuous monitoring during the wet weather period is needed to collect sufficient information. The number of monitor locations will depend on the layout of the sewer system. Monitors should be placed at key manholes where it is most important to have calibration information, or where it is necessary to define the characteristics of differing basins.

Model calibration is the critical step. For a particular storm event, you can compare the model-simulated overflow volumes and frequency to observed volumes and frequency observed in the field. The model's input co-efficients can be adjusted until the predicted overflows reasonably agree with the overflows of at least a few storms of varying size.

C. Data Analysis

The next step is to use the calibrated model to estimate total system and individual annual overflow frequency and volume for each year of rainfall record. The longer the reliable rainfall records, the better. (Note that the model uses the existing sewer system and the historical rainfall. So the results estimate the annual volumes which would have occurred for each year had the sewer system been as it is today.)

Plot the annual estimated overflow volume versus annual rainfall.

One graph could display the model's estimated correlation between rainfall and total CSO volume. Other graphs could address each individual CSO.

The next step is to draw confidence limits lines on the graph; for example, a 95-percent confidence limit line. (The overflow volume for any particular rainfall amount should not exceed a certain value 95 percent of the time.)

This is used to compare future CSO volumes to that which the graph predicts based upon a particular annual rainfall total. The regulation requires municipalities to measure and report their annual CSO volume. If the actual annual CSO volume for a few years exceeds a high confidence limit line, that should indicate that the CSO has increased above its baseline condition. Ecology would have a basis for requiring a municipality to accomplish a project to reduce the offending CSO to below its baseline condition.

For communities which (1) have little or no growth, and (2) are not scheduled to accomplish any significant sewer rehabilitation, construction, or CSO projects in the next few years, there is a simpler way to establish the baseline condition. Just monitor the overflow volumes and the rainfall. Draw the graph of rainfall versus overflow volume from the data. Draw the “baseline condition” line just above the data points.

The drawbacks of this latter approach are (1) it will have a limited number of data points from which to determine the baseline condition; and (2) it will not have the benefit of a model to help find cost effective reduction alternatives.

C3-2.1.4 Receiving Water

The objectives of receiving water monitoring generally include the following:

- Assess the attainment of water quality standards, including designated uses.
- Establish the baseline conditions in the receiving water.
- Evaluate the impacts of CSOs.
- Gain sufficient understanding of the receiving water to support evaluation of proposed CSO control alternatives, including any receiving water modeling that may be needed.
- Support the review and revision of water quality standards.

Identification and use of existing receiving water data can reduce the cost and effort of developing the CSO reduction plan. Often, pollutant source discharge, hydraulic, chemical, sediment, and biological data will exist because of past studies conducted in the watershed.

C3-2.1.5 Sensitive Areas

In developing CSO reduction plans, CSO communities are expected to give the highest priority to controlling overflows in sensitive areas, including:

- Designated outstanding national resource waters.
- National marine sanctuaries.
- Waters with threatened or endangered species and their habitats.
- Waters used for contact recreation, such as swimming and diving.
- Public drinking water intakes or their designated protected areas.
- Shellfish beds.

When physically and economically possible, eliminate or relocate those overflows that discharge to sensitive areas, treated or untreated.

C3-2.1.6 Site Ranking and Prioritization

Using the above information, a site ranking procedure should be developed that complies with WAC 173-245-040(d) and reflects the technical considerations discussed in this chapter and the larger needs of the community. Example approaches are given in EPA's document, "Combined Sewer Overflows—Screening and Ranking Guidance," 1995.

C3-2.2 Development of CSO Control Alternatives

Issues to consider when developing CSO control alternatives are listed in Table C3-2.

Table C3-2. Issues to Consider When Developing CSO Control Alternatives

Issue	Additional Comments
Identify ways to structure the alternatives, given the geographic layout of the CSO, as well as hydraulic and other constraints.	Specific items to identify: • Opportunities for consolidation of projects and regional solutions. • Projects common to all alternatives. • Projects requiring outfall-specific alternatives. • Opportunities to utilize treatment plant capacity—full secondary or CSO-treatment only using excess primary treatment capacity. • Sensitive receiving water areas: Outstanding National Resource Waters, National Marine Sanctuaries, waters with threatened or endangered species and their habitat, waters supporting primary contact recreation (e.g., bathing beaches), public drinking water intakes or their designated protection areas, and shellfish beds.
Institutional controls: consideration must be given to strengthening institutional controls over sources.	Institutional controls include: • Sewer use ordinances. • Industrial/commercial pretreatment programs.
Source controls: consideration must be given to methods to control the sources of volume and pollutants.	Source controls include: • Porous pavements. • Flow detention. • Area drain and roof leader disconnection. • Use of pervious areas for infiltration. • Air pollution reduction. • Solid waste management. • Street sweeping. • Fertilizer and pesticide control. • Snow removal and de-icing control. • Soil erosion control. • Commercial/industrial runoff control. • Animal waste removal. • Catch basin cleaning.

Issue	Additional Comments
Collection system controls: consideration must be given to methods to control the sources of volume and pollutants.	Collection system controls include: • Sewer line flushing and maintenance programs. • Maximizing use of existing system. • Sewer separation. • Infiltration/inflow control. • Polymer injection. • Regulating devices and backwater gates. • Inflatable dams. • Motor or hydraulically operated sluice gates. • Elastomeric tidegates. • Real-time control. • Flow diversion.
Storage technologies: consideration must be given to methods to store flows.	Methods of storage include: • Inline storage. • Offline near surface storage. • Deep tunnel storage. • Other (proven innovative or pilot-tested technologies).

Treatment technologies: consideration must be given to methods of treatment of overflows.	Methods of treatment include:
	• Centralized treatment
	  • Maximization of transfer of flows to the central treatment plant.
	  • Use of excess primary treatment capacity.
	  • Addition of primary or secondary capacity.
	• On-site treatment
	  • Offline near surface storage/sedimentation.
	  • Coarse screening.
	  • Swirl/vortex technologies.
	  • Disinfection.
	  • Dechlorination.
	  • Dissolved air floatation.
	  • High-rate filtration.
	  • Fine screens and microstrainers.
	  • Submerged discharge.
	  • Other (proven innovative or pilot-tested technologies).

Preliminary sizing considerations must be included in alternative development.	Preliminary sizing considerations include: • Predicted CSO flow rates, volumes, and pollutant loads under selected hydraulic conditions. • Level of abatement of predicted CSO volumes and pollutant loads necessary to meet CSO control goals.
Cost/performance considerations must be included in alternative development.	Cost/performance considerations include: • Comparing performance versus cost and identifying the point of diminishing returns, or “knee” of the curve. • Optimal combinations of storage, separation, and treatment facilities.
Preliminary siting issues must be included in alternative development.	Preliminary siting issues include: • Availability of sufficient space for the facility on the site. • Distance of the site from CSO regulator(s) or outfall(s) that will be controlled. • Environmental, political, or institutional issues related to locating the facility on the site.

Issue	Additional Comments
Preliminary operating strategies must be included in alternative development to ensure that the alternative can function reasonably in the context of its geographic location and relationship to the collection system.	

C3-2.3 Evaluation of CSO Control Alternatives

Final decisions on CSO control alternatives should take into account items listed in Table C3-3.

Table C3-3. Issues Affecting Evaluation of Final CSO Control Alternatives

Issue	Additional Comments
Project Costs	• Capital • Annual operations and maintenance • Life-cycle costs
Performance	• CSO control project performance • Impact on central plant performance
Cost/Performance Evaluations	
Technical Issues	• Constructibility • Reliability • Operability
Implementation Issues	• Adaptability to phased implementation • Institutional constraints • Multiple use considerations
Public Review and Comment	
Rating and Ranking of Alternatives	A system of rating and ranking project alternatives, based on consistent criteria such as described above should be developed as an evaluation tool. Examples are provided by EPA in section 3.4.5 of "Combined Sewer Overflows—Guidance for Long-Term Control Plan," 1995.

C3-2.4 Use of Models

Narrowing of alternatives should include detailed simulation of performance under a variety of actual storm conditions. Storms representing various return intervals should be selected from the record, with concentration on a storm selected to predict peak flows and volumes associated with approximately a once-per-year return period. The storms of interest can be selected from long-term monitoring records if available, or can be selected from a simulation of a long-term rainfall record using a simplified model. The use of synthetic design storms developed from intensity-duration-frequency curves should be avoided because they will over-predict the peak flow and under-predict the volume of runoff.

Confirmation of the expected performance of final alternatives should include detailed dynamic simulation of the system over several years of rainfall record. To ensure that an adequate once-per-year statistic is determined, the record should span at least five to six years with average annual rainfall approximately equal to the long-term average. (The rainfall during the late 1980s and early 1990s was below average while including several significant events with return periods on the order of 25 years or more. This period should be used with caution in long-term simulations.)

C3-3 Design Guidelines

The purpose of this section is to provide guidelines for the functional design of CSO control facilities.

C3-3.1 System Characterization

Functional design of CSO control facilities requires extensive understanding of the behavior of the system. Accurate assessment of overflow volumes and frequencies at all points in a complex system may require extensive monitoring of flows and rainfall, and use of a sophisticated mathematical model to analyze the data. In addition, data on the expected quality of combined sewer overflows is required to define the necessary reduction levels to meet water quality objectives and in design of quality control features.

C3-3.2 Structural Controls

C3-3.2.1 Sewer System Controls

Sewer system controls refer to utilization of the volume inherent in the sewer system to reduce overflows. For the majority of rainfall events, only a fraction of the depth in large diameter systems is occupied by the flow. Various devices have been used to take advantage of this “in-line” storage volume, including vortex throttle valves, inflatable dams, mechanical regulating gates, float operated gates, and static and bending weirs. This approach is the most cost-effective method to reduce overflow volumes.

Vortex throttle valves utilize flow resistance from a vortex action to effectively reduce the co-efficient of discharge in the standard orifice equation by a factor of approximately four. At heads up to about 150 percent of the valve diameter, the device behaves as a pipe with a diameter approximately twice that of the valve itself. Storage in upstream sewers, tanks, or on the streets (if installed in catch basins), is achieved with a significantly lower tendency for clogging than a standard orifice.

Design considerations for sewer system controls include the following:

- For static systems (weirs, throttle valves), consider optimal placement or sizing to minimize overflow volumes or frequency. This will require multiple analyses with continuous simulation models. With vortex throttle valves, consider the need for air venting and slide gates for clearing clogs and facilitating maintenance. Consideration should also be given to potentially serious plugging problems that could occur with the use of vortex valves.
- Installing a centralized computer control system with predictive models to adjust set points and flows within the system will optimize mechanical systems and maximize use of existing facilities.

- Emergency overflows must be provided to prevent backups in the system. This can include weirs upstream of control devices to bypass flow around the device when the storage reaches a maximum acceptable level.
- All overflows should be designed to retain solids and floatable materials within the sewer system.

C3-3.2.2 Reduction of Inflow Volume or Peak Rate

Inflow reduction includes stormwater separation that may include redirection of rooftop drainage to percolation areas or surface drainage systems. Reduction of peak flow rates can be accomplished by restricting flow at catch basin inlets, forcing storage in the streets or in small offline tanks associated with the catch basins, and utilizing available volume in the sewers.

- Partial separation for interception of street drainage only may be combined with programs for removal of rooftop drainage or additional storage for the remaining CSO. The total cost of separation with additional activities can be optimized. Consideration must be given to the regulatory requirements for stormwater discharge and the operational and maintenance costs associated with the new sewers.
- Removal of rooftop drainage design considerations includes the soil and drainage conditions at individual sites (avoid in landslide prone areas, or where drainage will collect in yards).
- Restricting or eliminating catch basin inlets can be used to store runoff on the streets or offline storage tanks. The streets and curb and gutter system can be used to direct surface drainage downstream to existing or new drainage systems. This technique, known as flow slipping, can reduce the total cost of stormwater separation. Design considerations include the additional depth of flow in gutter systems, and flooding of intersections (modifications may be required to allow flow to proceed downstream) and private property. These techniques are most effective when applied high in the tributary system.

C3-3.2.3 Storage

Storage (detention) of a large fraction of the CSOs for transfer to the central treatment plant may provide the greatest overall system pollutant reduction. Storage of combined sewage takes place in either inline or offline tanks. Inline systems have the storage tank as a part of the normal sewage flow path (tanks, enlarged sewer sections) with a flow control device at the downstream end. Offline systems require that excess flows enter the tank over a weir. A disadvantage of inline systems is that grit in the flow must pass through the system and may collect in the enlarged low velocity storage zone. Because the flow usually enters an offline system over a weir, grit is preferentially retained in the normal flow path, which may reduce operational cleanup efforts. Principal design considerations for storage are described in the following paragraphs.

A. Sizing

The volume of storage provided must be sufficient to result in overflows on an average of once per year. Since it may be difficult to provide additional storage in the future, the flow characterization of the network must be extensive enough to ensure selection of the proper sizing. Continuous simulation with several years of rainfall should be conducted to confirm sizing. The modeling should include the impacts of any upstream storage, which may affect the downstream units during tank drainage. The simulation should incorporate various drainage scenarios in order to optimize the overall system operation.

B. Impact on Downstream Treatment Facilities

Networks dominated by storage for CSO control will result in prolonged periods of higher-than-normal flow at downstream treatment plants. The impact of this operation must be assessed. It may be that this impact will necessitate holding stored flows until treatment plant flows have subsided significantly, which could result in large storage volumes to achieve overflow objectives.

C. Soil conditions

In poor soils, piling may be required to support the structures. In cases of high ground water, offline tanks will need provisions to prevent uplift. This may require that they be constructed near the ground surface, which may require that influent flows be pumped.

D. Cleaning

Storage facilities must be cleaned at various intervals ranging from immediately following each filling event to one time per year or longer.

E. Circular tanks

Introducing influent flows in a tangential manner facilitates cleanup of circular storage tanks. This sets up secondary currents that move solids to the center of the tank. The system may include recirculation pumps that maintain the vortex motion after flow subsides to further facilitate cleanup.

F. Rectangular tanks

Rectangular tanks should be constructed with multiple cells that are filled sequentially as the overflow event progresses. This minimizes the volume that must be cleaned up in smaller events, and concentrates heavier materials in the first cell. The arrangement is shown in Figure C3-1.

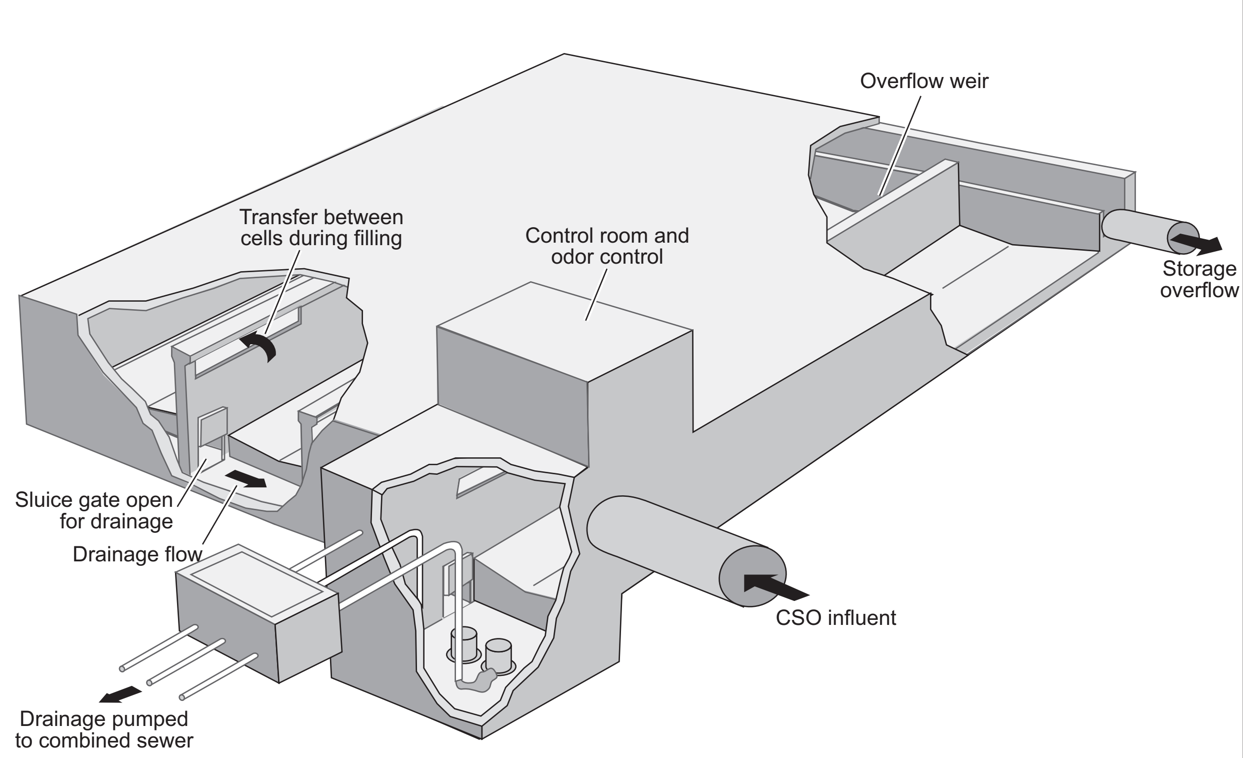

Figure C3-1. Rectangular Storage Tank Configuration

C3-3.2.4 Floatable Materials Control

Removing floatable materials is accomplished by using screens, fabric nets, rotary sieves, systems operating on the vortex principle, traps in catch basins, and simple underflow baffles in the overflow path. Floatable materials captures of up to 70 percent are expected.

Some example rotary sieve (similar to drum screens) specifications are as follows: sieve openings of 20 to 30 mm by 2 to 4 mm. Hydraulic loading rates of 100 L/m^2 are typical.

C3-3.3 CSO Treatment

Ecology permits the “equivalent” of primary treatment to achieve control of CSOs. Primary treatment is defined by Ecology as 50 percent suspended solids removal and an effluent settleable solids concentration less than 0.3 ml/L. Treatment of CSOs to remove suspended solids and associated pollutants is typically accomplished using plain (or primary) sedimentation, combinations of storage and treatment, vortex separation, inclined plate separation, high rate filtration, and microscreening. These methods can be supplemented by chemical addition (including ballast agents) and dissolved air floatation. (See C3-3.3.7 and Chapter T4.) CSO treatment facilities may operate only a few times each year. This intermittent operation must be considered in the design and measurement of performance.

C3-3.3.1 Permitting Issues

Ecology's policy is to interpret an annual mass balance approach for suspended solids. In this approach, suspended solids in CSOs stored in the treatment facility and pumped to a downstream secondary treatment plant after storm flows subside are credited as being removed according to the removal that occurs at the secondary plant. Removal is then calculated as the sum of suspended solids discharged from the CSO treatment facility and the mass of suspended solids discharged from the secondary facility in the transferred volume, divided by the mass of solids entering the CSO treatment facility, all on an annual basis.

C3-3.3.2 Primary Sedimentation

Design of primary sedimentation tanks is discussed in Chapter T2. In addition to those guidelines, information specifically for designing CSO treatment facilities is given below.

- The liquid depth in tanks for CSO treatment should be at least 9 feet, and consideration should be given to 15 feet to provide for storage of solids accumulated during a treatment event. Continuous sludge removal is not warranted due to the intermittent nature of operation and the short duration of discharge events. Continuous removal equipment would also interfere with cleanup after events.
- The removal of suspended solids by plain sedimentation is strongly dependent on the influent solids concentration and only moderately dependent on surface overflow rate. Experience with full-scale primary sedimentation plants and intermittent wet weather treatment plants indicates that the effluent TSS concentration remains essentially constant over a wide range of surface overflow rates. Ideally, the settling properties of solids in the specific CSO would be measured to select a peak overflow rate. In the absence of such data, a peak hourly overflow rate of 4,000 gpd/sf for the once-per-year design storm is recommended.
- The removal of suspended solids in any specific event depends mostly on the influent concentration and the portion of influent solids that are nonsettleable. Plain sedimentation is expected to achieve 50 percent suspended solids removal when averaged over an annual period.
- Settleable solids values resulting from primary treatment vary widely from day to day almost regardless of the flow and solids loading. Values have been observed ranging from nondetectable (less than 0.1 ml/L/hr) to over 5.0 ml/L/hr, but with a long-term average less than 0.3 ml/L/hr.

C3-3.3.3 Vortex Separation

Vortex solids separators use the vortex principle to move settleable solids to the bottom center of a circular chamber (see Figure C3-2). Flow is introduced on the tangent to induce the vortex motion. Solids-laden underflow is removed constantly at a rate of 5 to 15 percent of the influent flow. The relatively small diameter (40-foot maximum) and the steeply sloping sides provide an advantage in cleanup after treatment events. Enhancement of performance by addition of dissolved air floatation is also facilitated by the configuration.

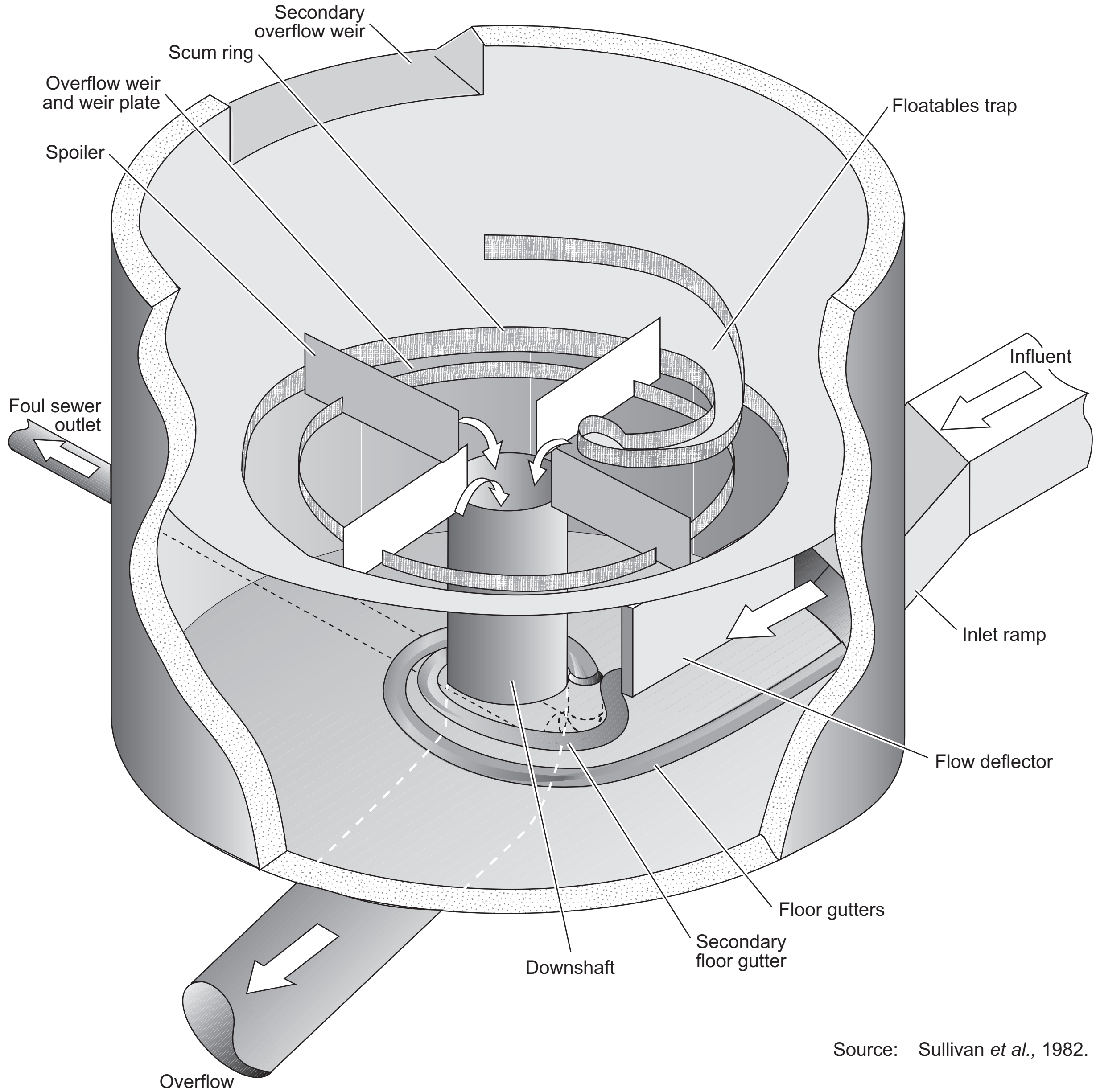

Figure C3-2. Schematic of the Swirl Concentrator

There are two commercially available vortex separators and the US EPA Swirl Concentrator. The vendors furnish design considerations. Additional design issues are as follows:

- Suspended solids removal above 50 percent on the basis of influent and effluent concentration has been reported for surface overflow rates less than about 7,500 gpd/sf (5 gpm/sf). Performance reported in the literature ranges from 5 to 80 percent. Most data from the literature is taken from tests at influent suspended solids concentrations greater than 200 mg/L. In the absence of site specific testing or enhancements (e.g., dissolved air floatation), a peak surface overflow rate of 4,000 gpd/sf during the one-year design event is recommended.

- Vortex separators require a constant removal of settled solids from the bottom of the unit. This flow stream is usually 10 to 15 percent of the influent flow rate. This stream can be returned to the sewer system if there is sufficient capacity. Otherwise, it must be stored in offline tanks until capacity exits.

C3-3.3.4 High Rate Filtration

Filtration, using deep bed dual media, shallow bed sand, and compressed synthetic media filters, has been used to treat CSOs. Shallow bed filters have been tested extensively on primary effluent and found to generally reduce suspended solids by 50 percent. See Chapter T4 for further information.

C3-3.3.5 Microscreening

Microscreens with 23-mesh screen materials have exhibited effluent suspended solids concentrations in the range of 40 to 60 mg/L with influent CSO concentrations of 50 to 300 mg/L. Thus, the performance of the screen is dependent on the influent concentration, and, like primary sedimentation, 50-percent removals will not occur if the influent concentration drops much below 100 mg/L. See Chapter T4 for further information.

C3-3.3.6 Inclined Plate Separators

The use of inclined plate separators increases the effective settling area of a sedimentation unit. Inclined plates can be used to increase the allowable surface overflow rate on a sedimentation unit. A significant increase in suspended solids removal should not be expected, however, unless this technique is combined with chemical treatment. See Chapter T2 for further information.

C3-3.3.7 Chemical Treatment

Chemical treatment is the addition of coagulants to enhance sedimentation, filtration, and dissolved air flotation. Coagulants normally used include aluminum, iron salts, and/or polymers. The precipitates formed are coagulated together with CSO particulates into larger, rapidly settling floc. Coagulating otherwise nonsettleable solids increases suspended solids removal. In addition, ballast agents (fine sands) can be added to enhance the settling velocity of the flocs, increasing the allowable surface overflow rates needed in sedimentation processes. Chemical treatment is often combined with inclined plate separation to further reduce unit sizes. Chemical treatment with metals salts will achieve a high degree of removal of heavy metals, high molecular weight organic pollutants, and coliform bacteria.

Adding microsands to enhance the settling velocity of chemical flocs is a recent advancement. When combined with ferric chloride, polymer, and inclined plate separation, suspended solids removals from stormwater of 80 to 90 percent have been reported at surface overflow rates up to 60,000 gpd/sf. The disadvantage of these processes is the chemical usage (up to 100 mg/L ferric chloride) and loss of fine sand. The sand is recycled, but losses up to 2 mg/L of treated CSO are reported.

See Chapter T4 for further information.

C3-3.3.8 Disinfection

On-site treatment of CSOs may include a disinfection requirement at CSO sites that are near or that impact water supply intakes, potentially harvestable shellfish areas, and primary contact recreation areas. Disinfection of CSOs is accomplished with oxidizing chemicals (chlorine, calcium, or sodium hypochlorite), chlorine dioxide, bromine based compounds, ozone, or ultraviolet light. Contact time may be provided in CSO treatment or storage facilities by dosing ahead of the tanks.

The following criteria are appropriate for performance:

- End-of-pipe fecal coliform concentration of 400 counts/100 ml.
- Receiving water quality requirements met by ensuring that bacterial counts at the boundary of the chronic mixing zone are within water quality criteria.
- Regulatory flows for dilution calculations are as follows:
    - **Maximum day:** average discharge rate during the one-per-year design event.
    - **Maximum month:** compute average monthly discharge as the sum of discharge volumes during each month divided by the number of discharges in that month. Select the 95th percentile value from long-term simulations as the maximum monthly flow.
- Unless initial dilution is sufficient, dechlorination will be required to meet water quality standards for chlorine.

See Chapter T5 for further information.

C3-3.4 Operations and Maintenance Considerations

The purpose of this section is to provide considerations for operations and maintenance for CSO control, including the following:

- Frequency and timing.
- Access.
- Cleaning and maintenance considerations.
- Monitoring.

Operation and maintenance considerations of CSO facilities will be largely dependent on site-specific factors. A program should be developed that clearly establishes operation, maintenance, and inspection procedures to ensure the specific system will function to maximize treatment of combined sewage and comply with NPDES permit limitations. Proper design of CSO facilities necessitates consideration of operation and maintenance requirements.

C3-3.4.1 Frequency and Timing

It can be anticipated that maintenance of CSO facilities will include inspections after each wet weather event. Additionally, inspection on an established schedule (weekly, monthly, etc.) between events is advisable. Frequency of inspection will depend on the type of facilities, historic records of performance and reliability, sensitivity of nearby surface waters to CSOs, adequacy of maintenance program, and other items.

Detention-type facilities may only require an inspection at the beginning of each wet season and after each wet weather event. However, if the facilities have not been designed to provide some level of self-cleaning, it will be necessary to provide for settled solids removal after each event to control odors and corrosive gases.

Facilities incorporating processes beyond detention, such as intermittently operated CSO treatment plants and regulator structures, should have routine scheduled visits and equipment checks by maintenance personnel or operators. Maintenance of the facilities would be as established by the equipment requirements. An operator may be assigned to the facility when the plant becomes active. The operator generally is not required to activate the plant but is required to monitor the operation to assure continuous operation in the event of a device malfunction. Plants using reliable equipment and which are totally automatic may not require inspection during operation unless equipment malfunction alarms a central location whereby maintenance personnel could be notified. Following a wet weather event it would be typical for maintenance personnel to dewater and wash down the facility to prepare for the next event unless provisions in the facility design accommodate these functions (such as automatic washdown).

A properly developed operation and maintenance program should be integral to the overall operation of the system. While some operational problems may be mitigated by appropriate design, regular inspection and maintenance must be provided if the system is to function satisfactorily.

C3-3.4.2 Access

Normal inspection and maintenance of CSO facilities requires that adequate access be provided. Access openings are required for:

- Personnel entry.
- Transportation of equipment and materials.
- Ventilation.
- Light shafts.

Personnel access at larger detention-type facilities may be provided by incorporation of a permanent stairway in the design. For smaller detention-type facilities a permanently installed ladder may adequately serve the purpose. Applicable fall protection considerations should be incorporated. If possible, access from an aboveground building which might also house electrical controls and valving might provide the most convenient option. Larger facilities may be also be provided with inspection walkways inside the basin. These walkways provide a convenient method of inspection and will promote more frequent visits and better maintenance. Intrusion alarms on access openings should be considered if a high level of protection and security is desired.

Access openings may be required above basin inlets and outlets and at other locations where settled solids may necessitate cleaning. These openings should provide capability to unplug the outlet when the basin is full. Consideration should be given to locating these openings to provide ventilation and light shafts.

C3-3.4.3 Cleaning and Maintenance Considerations

When a CSO facility is designed, consideration must be given to cleaning. If the facility remains full of solids or overflow for long periods of time due to lack of automated controls or personnel, septic conditions and odor problems will occur. The following design factors should be considered:

- Manual or automated washdown.
- Potable or nonpotable water available.
- Use of decant water off storage tank for rinsing and cleaning.
- Tank bottom sloped for ease of cleaning and solids removal.
- Floatable materials:
    - Retain in storage/treatment tank.
    - Remove, dewater, and haul to landfill.
    - Dewater and transport to wastewater treatment plant.
- Assess whether solids can be pumped to the wastewater treatment plant for processing.
- Degrit solids at CSO facility and transport grit to landfill.
- Use permanent or portable pumps to dewater facility.
- Transport all floatable materials, solids, and liquid to wastewater treatment plant after CSO event.

C3-3.4.4 Monitoring

Monitoring CSO occurrences is used to assess the extent of and changes in pollutant loading or receiving water characteristics. Visual inspections and other simple methods may be used to determine the occurrence and apparent impacts of CSOs.

Recording of overflow volume and frequency for each outfall is required by Ecology (Chapter 173-245 WAC) and EPA (59 FR 18688). At a minimum, the date, time, and duration of each overflow event should be recorded by visual observation or flow or level sensor. Total daily rainfall for that event should also be measured and recorded. Magnitude of the overflow event ideally should be measured and characterized by flowmeter.

C3-3.5 Redundancy

The purpose of this section is to clarify application in a wet weather intermittent flow system. Redundancy and reliability are generally covered in Chapter G2.

Redundancy in the CSO context refers to mission-critical facilities necessary to protect equipment, human life, and public health. This would include systems necessary to ensure that excessive pressures do not occur in sewers; for example, emergency overflows, backup power systems to operate flow regulating valves, etc. In addition, systems for drainage of tanks should also have redundancy in the form of multiple units.

CSO control systems should be designed for operation of all associated equipment at the once-per-year frequency level. This means that under most operating conditions, not all the equipment (pumps, tanks, valves, etc.) will be in use. In addition, the frequency of operation is intermittent. As a result, the treatment equipment will not normally require redundant units because there will be units not in operation during the majority of events (for example, a spare pump or primary sedimentation unit). Spare influent or effluent pumps are not required unless flow conditions are such that all the pumps are required to operate several times per year.

C3-4 Submittal Requirements

Ecology's CSO reduction program requirements are included in Chapter 173-245 WAC, "Submission of Plans and Reports for Construction and Operation of Combined Sewer Overflow Reduction Facilities." The following paragraphs summarize the submittals which are unique to CSO projects.

C3-4.1 CSO Reduction Plan

Municipalities were mandated to obtain Ecology's approval for CSO reduction plans by Jan. 1, 1988. This deadline was extended in many cases.

The CSO reduction plan should be sufficiently complete so that plans and specifications can be developed from it for projects that may proceed into design within two years of plan submittal. Sufficient detail of any remaining projects should be provided such that detailed engineering reports can be prepared. Further requirements for the contents of a CSO reduction plan may be found in WAC 173-245-040.

C3-4.2 Engineering and Construction Submittals

The following requirements are the same as the general engineering requirements. See Chapter G1.

- Engineering reports.
- Plans and specifications.
- Construction quality assurance plan.
- Operation and maintenance manual.
- Declaration of construction completion.
- Requirements for certified operator(s).
- Ownership and operation and maintenance.

C3-4.2.1 Engineering Reports for CSO Projects

In adopting a CSO Reduction Plan, a municipality should identify a schedule for its projects. Before implementing any of those projects, a municipality must submit a project-specific engineering report or facility plan. The facility plan is a prerequisite to applying for a grant or loan for design and construction.

The engineering report or facility plan should be at a level of detail equivalent to that outlined in WAC 173-240-060. For instance, it should include an identification of the site, a general site layout, and the design criteria for any on-site CSO treatment project. For a sewer separation project, it should include a plan view of the new storm or sanitary sewer layout for the basin, and the sizes and preliminary elevations of the sewers. In addition, the report should include an assessment of the environmental impacts of the proposed projects.

C3-4.2.2 Source Control and BMP Requirements

Engineering reports for sewer separation projects should also include a scope of work to accomplish a drainage basin survey and source control effort for all direct and indirect (such as an industrial storage yard runoff into the street) industrial and commercial stormwater contributions. The purpose of the survey and source control efforts is to reduce the pollutant load into the new storm sewer.

The municipality should substantially complete its initial source control effort before submitting plans and specifications for the separation project to Ecology for approval. A source control report should accompany the plans and specifications submittal. These source control efforts should be integrated with the municipality’s stormwater NPDES permit and/or comprehensive stormwater program.

C3-4.2.3 Environmental Assessment

The engineering report for a CSO project should document the extent of the sediment impacts of the existing CSO discharge. These studies will establish an environmental baseline against which to monitor the extent of water quality improvements gained by the project. The municipality may have reported sediment quality analyses as part of their CSO reduction plan. As allowed by the rule and guidance, residential basins may have had only a qualitative assessment of sediment impacts in the CSO reduction planning stage.

The report should also include a discussion of the estimated environmental impacts of the project (i.e. new storm sewer outfall, on-site treatment, or reduced CSO frequency because of storage). Those portions of the environmental assessment done for the CSO reduction plan could be referenced. If an environmental assessment of the proposed project was not done for the CSO reduction plan, it should certainly be done now. The municipality should give at least a qualitative discussion of the stormwater quality improvements expected as a result of implementing source control measures and BMPs.

C3-4.3 Annual CSO Report

Municipalities with approved CSO reduction plans are required to submit annual CSO reports to Ecology. This report must include the past year’s frequency and volume of combined sewage discharged from each CSO site, or group of CSO sites in close proximity. Field monitoring will be necessary to estimate these parameters. If there is a statistically significant increase in the CSO volumes above the baseline over a few years, the municipality must propose a project and schedule to reduce the CSO site or group of sites to or below its baseline condition.

For CSO on-site treatment and discharge, monitoring and reporting requirements will be included in the appropriate sewage treatment plant NPDES permit or in a separate permit for that discharge. The total treated and untreated annual discharge from an on-site treatment plant may not increase above the baseline annual level.

The annual report should explain the previous year's CSO reduction accomplishments and list the projects planned for the next year.

C3-4.4 CSO Plan Update/Amendment

In conjunction with its application for renewing its NPDES permit, a municipality with CSOs must submit an amendment which updates its CSO reduction plan. The amendment should include:

- An assessment of the effectiveness of the CSO reduction plan to date.
- A reevaluation of the CSO site's project priority ranking.
- A listing of projects to be accomplished in the next five years based on priorities and estimated revenues.

C3-5 References

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